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Hans Fehr • Manuel Kallweit • Fabian Kindermann

Marital Risk, Family Insurance, and Public Policy

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Marital Risk, Family Insurance, and Public Policy‡

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Abstract

The present paper aims to quantify the growth and welfare consequences of changing family structures in western societies. For this reason we develop a dynamic general equilibrium model with both genders which takes into account changes of the marital status as a stochastic process. Individuals respond to these shocks by adjusting savings and labor supply.

Our quantitative results indicate that the declining number of marriages coupled with increasing divorce rates had a profound effect on macroeconomic variables and long-run welfare. We find a significant increase in aggregate capital accumulation and a rising labor market participation of women. In addition, our simulations indicate that the change in the marital structure had significant negative welfare consequences for women who lost between 0.4 and 2.2 percent of aggregate resources. The impact on men's welfare, however, could be positive or negative depending on the specific calibration.

JEL Classification: J12, J22
Keywords: family formation, stochastic general equilibrium, life cycle model

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1 Introduction

Almost all western societies are currently experiencing an unprecedented two-dimensional demographic change. On the one side, low fertility and reduced mortality rates change the age structure of the population. On the other side, declining marriage and increasing divorce rates radically alter the traditional family structure within cohorts. While in the past long-term marriage combined with gender specialization was a near-universal adult experience, only a minority follows this role model nowadays. In Europe the total first marriage rate (TFMR) for women, which was close to one in the after-war period, has reached 0.58 on average in year 2004 ranging from low rates of 0.41 in Slovenia to 0.75 in Denmark, see CEP (2006). During the same period, the average European total divorce rate (TDR), which indicates the probability of a married person being divorced, has increased from roughly 10 percent to 0.32 in 2004. Here, we observe an even stronger variation with low divorce rates still prevailing in countries such as Italy (0.13) or Spain (0.10) and high rates in countries like Sweden (0.52) or Belgium (0.56). Compared to Europeans, Americans marry and divorce at higher rates, but the time trend is quite similar, see Stevenson and Wolfers (2007).

More singles and less stable marriages affect individual labor supply, consumption and savings behavior which may in turn severely affect the macroeconomy. In addition, since family may be interpreted as an (incomplete) insurance contract (Kotlikoff and Spivak, 1981), changing family structures will also affect the role of government provided social security. The past literature has explored these issues by focusing mostly on the effect of marriage and divorce risk on labor supply (especially of the female spouse) in static household models. Johnson and Skinner (1986) already argued that the increased divorce probability has a significant positive impact on female participation rates in the USA. Stevenson (2008) confirms this finding by analyzing the past changes in divorce law (which increased marriage instability). In principle, marriage and divorce can be viewed as costly events so that increased marital risk induces – similarly as rising income risk – precautionary behavior. Therefore, the positive relationship between divorce probability and female labor supply is significant in the intertemporal labor supply model by Papps (2006), where married partners both choose their labor supply simultaneously. Surprisingly, this study also finds that higher marriage probabilities have a positive effect on singles' labor supply. Especially for women who expect to marry a partner with higher income, one would expect the opposite. But – as suggested by Papps (2006, p. 30) – maybe these women already take into account the possible divorce after marriage.

If marital risk induces precautionary behavior, then increased divorce rates should also increase individual savings. However, since assets are typically split after a divorce, rising divorce rates may also work in the opposite direction and increase individual consumption.

In order to quantify the impact of divorce probabilities on savings, Gonzalez and Özcan (2008) take the introduction of divorce law in Ireland in 1996 as a natural experiment. After 1996 divorce rates and consequently divorce risk for married couples rose significantly in Ireland. At the same time, the Irish savings rate increased significantly stronger than in other European countries. Since the reaction of the savings rate is especially strong for non-religious married couples who experience the most significant increase in divorce risk, Gonzalez and Özcan (2008) argue that divorce risk increases savings.

Our paper is related to a recent literature of calibrated models on the economics of the family, such as Erosa et al. (2002), Chade and Ventura (2002), Caucutt et al. (2002) or Da Rocha and Fuster (2006). Most of these papers either deal with marriage issues or concentrate on the relationship between fertility and labor supply decisions. We abstract from endogenous marriage and fertility and model changes in marital status as exogenous shocks. We then focus on the interaction between marriage and divorce rates and individual labor supply and savings. Some attempts have already been made in order to introduce marital risk in stochastic life-cycle simulation models. Love (in press) includes marriage and divorce risk in a partial equilibrium model with labor income and investment uncertainty in order to analyze optimal portfolio choice. The present study mainly builds on the general equilibrium approach of Cubeddu and Rios-Rull (2003) who extend the standard overlapping generations model in the Auerbach and Kotlikoff (1987) tradition by explicitly accounting for marital transitions during the life-cycle. Simulating the long-run consequences of alternative marriage patterns, they find that changes in family structures have a significant effect on aggregate savings. While rising divorce risk increases precautionary savings, the actual net contribution depends on specific institutional features such as asset splitting rules, divorce costs and remarriage patterns.

The present study extends this approach in various directions. First, while Cubeddu and Rios-Rull (2003) abstract from labor supply issues, our model allows for endogenous labor supply and household production of both partners of the marriage. Second, we introduce income and lifespan uncertainty as well as mating across education types in order to quantify the insurance provision of marriages. Third, we analyze the effects of progressive income taxes with joint filing. Finally, in contrast to Cubeddu and Rios-Rull (2003) we simulate a change in *aggregate* marriage and divorce rates and compute the resulting welfare consequences for both genders.

Our model is calibrated with current German marriage and divorce probabilities. This benchmark equilibrium is compared with alternative long-run equilibria which result from marital transition probabilities from the 1970s. Our quantitative results indicate that the declining number of marriages coupled with increasing divorce rates had a profound effect on macroeconomic variables and long-run welfare. We find a significant increase in aggregate capital accumulation and a rising labor market participation of women. In addition, our simulations indicate that the change in the marital structure had a significant negative welfare impact on women who lost between 0.4 and 2.2 percent of aggregate resources. The impact on men's welfare, however, could be positive or negative depending on the specific calibration.

The next section describes the structure of the simulation model. Section 3 explains the calibration and simulation approach. Finally, section 4 presents the simulation results and section 5 offers some concluding remarks.

2 The model economy

2.1 Demographics and intracohort heterogeneity

We consider an economy populated by overlapping generations of individuals which may live up to a maximum possible lifespan of J periods. At the beginning of each period, a new generation – half of them are male m, half of them female f – is born, where we assume a population growth rate n. Individuals face gender-specific lifespan uncertainty, where $\psi_j^g \leq 1$ denotes the conditional survival probability of gender $g \in \mathcal{G} = \{m, f\}$ from age $j-1$ to age j with $\psi_{J+1}^g = 0$.

Our model is solved recursively. Consequently, an age-j agent faces the state vector

$$z_j = (g, s, m_j, e_j, e_j^*, \mathrm{a}_j, ep_j), \tag{1}$$

where $s \in \mathcal{S} = \{1, \ldots, S\}$ denotes agent's skill level and $m_j \in \mathcal{M} = \{0, \ldots, S\}$ his marital status, i.e. if $m_j = 0$, the agent is single, if $m_j \in \mathcal{S}$, he is married to a spouse of educational group $s^* \in \mathcal{S}$. $e_j \in \mathcal{E} = (0, \infty)$ and $e_j^* \in \mathcal{E}$ state the agent's and the possible partner's productivity. $\mathrm{a}_j \in \mathcal{A} = [0, \bar{\mathrm{a}}]$ and $ep_j \in \mathcal{P} = [0, \overline{ep}]$ define assets and accumulated earnings points of the pension system held at the beginning of age j, respectively.

At the beginning of the life-cycle working period, each agent is assigned to an educational group and a marital status, where the educational background remains constant over time and the marital status m_j changes due to exogenously specified demographic parameters. At the end of each period, surviving married individuals get divorced with probability π_j^d, while single individuals get married with probability π_j^m. Since we distinguish different educational backgrounds, we specify the probability $\pi_{ss^*}^g$ which indicates the likelihood that an individual of gender g and education class s gets married to a spouse of gender g^* and skill group s^* with $\sum_{s^*=1}^{S} \pi_{ss^*}^g = 1$ for $g \in \{m, f\}$. If a married individual gets divorced or his/her spouse dies his/her marital status returns to single.

Agent's productivity e_j, as well as the productivity of the possible spouse, is stochastic, where we assume $\pi_s(e_{j+1}|e_j)$ to be the probability density function of a skill group s household's productivity e_{j+1} at age $j+1$ if current productivity is e_j. In the following, we will omit the state index z_j for every variable whenever possible. Agents are then only distinguished according to their age j.

2.2 The problem of single men and women

Our model assumes a preference structure that is represented by a time-separable, nested CES utility function.[1] The single consumer at age j and state $z_j = (g, s, 0, e_j, 0, a_j, ep_j)$ – i.e. income class s – solves the individual problem

$$V(z_j) = \max_{c_j, \ell_j} \quad \left\{ u\left(c_j, \ell_j\right) + \delta \psi^g_{j+1} EV(z_{j+1}|z_j) \right\}^{\frac{1}{1-\frac{1}{\gamma}}} \tag{2}$$

by choosing goods and leisure consumption c_j and ℓ_j, respectively.

Expected utility in future periods is discounted with δ and, since lifespan is uncertain, weighted with the gender-specific survival probability ψ^g_{j+1}. The intertemporal elasticity of substitution is γ. The expectation operator E in (2) indicates that future utilities are computed over the distribution of e_{j+1} and m_{j+1}. If the agent stays single with a probability of $1 - \pi^m_{j+1}$, he enjoys regular single utility and his state moves to $z_{j+1} = (g, s, 0, e_{j+1}, 0, a_{j+1}, ep_{j+1})$. However, if he gets married to an agent of same age with probability π^m_{j+1}, his future state will be

$$z_{j+1} = \left(g, s, s^*, e_{j+1}, e^*_{j+1}, \frac{a_{j+1} + a^*_{j+1}}{2}, \frac{ep_{j+1} + ep^*_{j+1}}{2} \right), \tag{3}$$

where $s^*, e^*_{j+1}, a^*_{j+1}$ and ep^*_{j+1} denote educational background, productivity, assets and earning points of the possible future spouse. Single agents take into account the mating probabilities $\pi^g_{ss^*}$ and form expectations over future spouses productivity, assets and earning points according to the distribution of singles of gender g^* over the state space at age j. Note that, if two agents get married, their assets and earning points will be pooled, which highlights the risk sharing aspect of marriage but exaggerates the common practice in Germany.[2]

Singles maximize (2) subject to the budget constraint (4),

$$\mathrm{a}_{j+1} = (1+r)\mathrm{a}_j + w_j + p_j + b_j - \tau \min[w_j; 2\bar{w}] - T(y_j) - (1+\tau_c)c_j \tag{4}$$

[1] The utility function we use here is a monotonic transformation of the original CES utility function which guarantees that utility is bound from below by 0. This is just for computational reasons.

[2] The pooling of resources could be a necessary precondition for marriage when marriage partners play a Nash-bargaining game on the wedding day, see Wrede (2003, p. 208). However, as Siermiska, Frick and Grabka (2008) report, only roughly 15% of couples in Germany experience equal sharing within their households.

with $\text{a}_1 = \text{a}_{J+1} = 0$. In addition to interest income from savings $r\text{a}_j$, unmarried individuals receive gross labor income $w_j = w(1-\ell_j)e_j$ during their working period as well as public pensions p_j during retirement. As time endowment is normalized to one, w defines the wage rate for effective labor. Households may also receive accidental bequests b_j and have to pay social security contributions and income taxes. Contributions at a rate τ are paid to the public pension system up to a ceiling which amounts to the double of average income $\bar{w}$. Income taxes depend on taxable income y_j and the tax schedule $T(\cdot)$ which is explained below. Finally, the price of consumption goods c_j includes consumption taxes τ_c.

2.3 The problem of married couples

In our benchmark we assume a collective model of household decision making. Consequently, married couples of skill groups s and s^* at age j maximize a joint welfare function with equal weights in order to obtain efficient outcomes[3]

$$\max_{c_j,\ell_j,\ell_j^*} \left\{ u(c_j,h_j) + \delta\psi_{j+1}^{g} EV(z_{j+1}|z_j) \right\}^{\frac{1}{1-\frac{1}{\gamma}}} + \left\{ u(c_j,h_j) + \delta\psi_{j+1}^{g^*} EV(z_{j+1}^*|z_j^*) \right\}^{\frac{1}{1-\frac{1}{\gamma}}} \tag{5}$$

subject to the household budget constraint (6) for married couples which reflects the pooling of resources during marriage and the income splitting method of family taxation, i.e.

$$\begin{aligned} 2\text{a}_{j+1} = {} & (1+r)2\text{a}_j + w_j + w_j^* + p_j + p_j^* + b_j + b_j^* \\ & - \tau\ \big(\ \min[w_j;2\bar{w}] + \min[w_j^*;2\bar{w}]\ \big) - 2T\left(\frac{y_j+y_j^*}{2}\right) - 2(1+\tau_c)c_j. \end{aligned} \tag{6}$$

Note that married couples in our benchmark are not altruistic and don't receive direct utility from being married, i.e.

$$V(z_j) = \left\{ u(c_j,h_j) + \delta\psi_{j+1}^{g} EV(z_{j+1}|z_j) \right\}^{\frac{1}{1-\frac{1}{\gamma}}}. \tag{7}$$

We follow Konrad and Lommerud (1995), Saint-Paul (2008) or Barham, Devlin and Young (2009) and assume that married couples produce a family public good (such a well-educated children, a clean house or a beautiful garden) from leisure contributions of both partners. Consequently, consumption of the family public good is derived from

$$h_j = \varphi\left(\ell_j^m\right)^{\kappa}\left(\ell_j^f\right)^{1-\kappa} \quad , \quad \varphi \geq 1, \tag{8}$$

[3]See Apps and Rees (2009, p. 36ff.) for a survey of different family models.

where the parameter φ measures the magnitude of the external effect and κ is a share parameter for male input. Since collective consumption of married couples is identical by definition, optimal consumption of private goods must be the same for both partners, i.e. $c_j = c_j^*$.

We assume that married couples split their savings during marriage equally. If one of the partners dies at the end of the period, the surviving spouse receives all of the couple's assets. Beneath the productivity processes for both partners, married agents takes into account three different scenarios: The first of them reflects the situation when the marriage continues with probability $1 - \pi_{j+1}^d$ in the next period and the spouse survives. In this case, the future state is simply $z_{j+1} = (g, s, s^*, e_{j+1}, e_{j+1}^*, \mathrm{a}_{j+1}, ep_{j+1})$. The second case covers the situation when one of the spouses dies. The status of the surviving partner, e.g. the partner of gender g, then turns into $z_{j+1} = (g, s, 0, e_{j+1}, 0, 2\mathrm{a}_{j+1}, ep_{j+1})$, i.e. assets are completely inherited to the remaining spouse. Finally, the third case describes the situation when the marriage is divorced. Here, the individual status changes to $z_{j+1} = (g, s, 0, e_{j+1}, 0, \mathrm{a}_{j+1}, ep_{j+1})$, where we assume that assets and earning points are split.

2.4 Instantaneous utility, earning points and accidental bequests

The period utility function is defined by

$$u(c_j, \ell_j) = \left[(c_j)^{1-\frac{1}{\rho}} + \alpha(\ell_j)^{1-\frac{1}{\rho}} \right]^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}}, \tag{9}$$

where ρ denotes the intratemporal elasticity of substitution between consumption and leisure at each age j and γ defines the intertemporal elasticity of substitution between consumption in different years, while α defines the age-independent leisure preference parameter. Of course, ℓ_j has to be changed to h_j in (9) in the case of married couples.

Accumulated earning points of the pension system depend on the relative income position $w_j/\bar{w}$ of a worker at working age $j < j_R$. Since the contribution ceiling is fixed at the double of average income $\bar{w}$, maximum earning points collected per year are 2. Therefore, for a single, earning points accumulate according to

$$ep_{j+1} = ep_j + \min[w_j/\bar{w}; 2], \tag{10}$$

where $ep_1 = 0$. For married couples, earning points are split during the whole marriage, which approximates both the German pension rights adjustment and widow's pension benefit system.

Our model abstracts from annuity markets. Consequently, private assets of agents who died are aggregated and then distributed equally among all working age cohorts $j < j_R$. Note, that couples' assets are only passed on to younger cohorts if both partners die at the end of the same period. If a spouse survives, she inherits the complete assets of the partner.

2.5 The production side

Firms in this economy use capital and labor to produce a single good according to a Cobb-Douglas production technology $Y = \theta K^{\varepsilon} L^{1-\varepsilon}$ where Y, K and L are aggregate output, capital and labor, respectively, ε is capital's share in production and θ defines a technology parameter. Capital depreciates at a rate δ_k. Firms maximize profits renting capital and hiring labor from households such that net marginal products equal r the interest rate for capital and w the wage rate for effective labor.

2.6 The government sector

Our model distinguishes between the tax and the pension system. In each period of the long-run equilibrium, the government issues new debt nB_G and collects taxes from households in order to finance general government expenditure G which is fixed per capita as well as interest payments on its debt, i.e.

$$nB_G + T_y + \tau_c C = G + rB_G, \tag{11}$$

where T_y defines revenues from income taxation and C aggregate consumption.

We assume that contributions to public pensions are exempted from tax while benefits are fully taxed. Consequently, taxable income y_j is computed from gross labor income net of pension contributions, a flexible work related allowance $d(w_j)$, capital income above a specific allowance level d_s and – after retirement – public pensions. Given taxable income, we apply the German progressive tax code of the year 2005 and balance the budget of the government by adjusting the consumption tax rate.

In each period, the pension system pays old-age benefits and collects payroll contributions from wage income below the contribution ceiling of $2\bar{w}$. Individual pension benefits p_j of a retiree at age $j \geq j_R$ in a specific year are computed from the sum of accumulated earning points ep_{j_R} which are multiplied by the actual pension amount (APA) per earning point. The budget of the pension system must be balanced in every period.

2.7 Equilibrium conditions

In addition to factor prices being equal to marginal products, for a long-run equilibrium, we need households to maximize (2) and (5) with respect to the respective constraints (4) and (6), an invariant measure of households ξ over the whole state space and market clearance for capital, labor and goods market.

3 Calibration of the initial equilibrium

3.1 Parameterizing the model

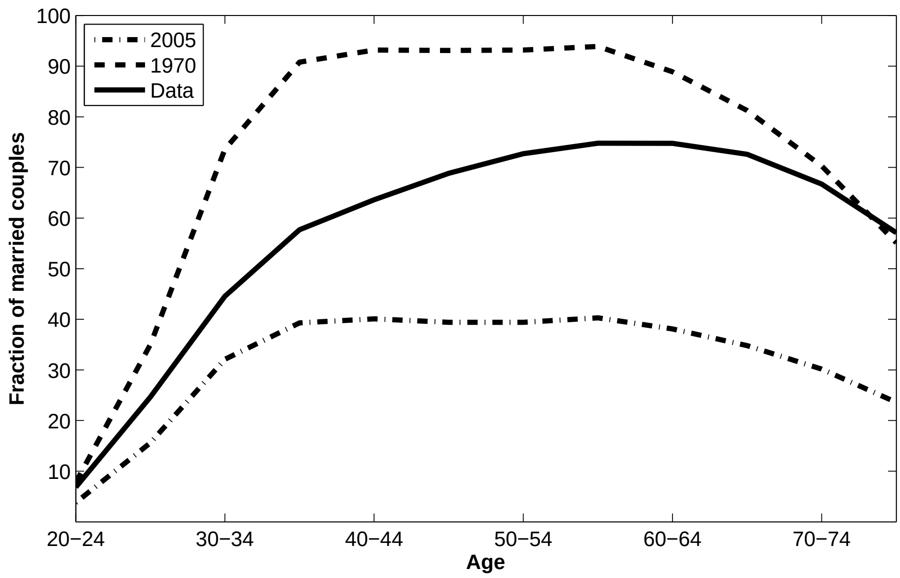
Table 1 reports the central parameters of the model. In order to reduce computational time, each model period covers five years. Agents start life at age 20 ($j = 1$), are forced to retire at age 60 ($j_R = 9$) and face a maximum possible life span of 100 years ($J = 16$). The population growth rate is set at $n = 0.051$ which roughly corresponds to an annual growth rate of 1 percent. Since population growth is close to zero in Germany, this figure mainly reflects labor productivity growth. The conditional survival probabilities ψ_j^g are computed from the year 2000 Life Tables for Germany reported in Bomsdorf (2003). However, in order to simplify the demographic transition, we assume gender-invariant survival probabilities up to retirement, i.e. $\psi_j^f = \psi_j^m = \psi_j, j < j_R$. We also restrict (mainly for computational reasons) marriage, divorce and re-marriage to working periods. After retirement, single individuals remain single until death while married couples could only become widows/widowers. Age-specific marriage and divorce probabilities π_j^m and π_j^d up to retirement are derived from cohort data reported in the Statistical Yearbook of the Federal Statistical Office Germany (2007). Figure 1 shows the fraction of married couples in each cohort we obtain when applying our estimated marriage and divorce probabilities for 2005 to the model. We see an

Table 1: Parameter selection

Demographic parameters	Preference parameters	Technology parameters	Government parameters
$J = 16$	$\gamma = 0.6$	$\theta = 1.52$	$\tau_c = 0.17$
$j_R = 9$	$\rho = 0.6$	$\varepsilon = 0.3$	$B_G/Y = 0.6$
$n = 0.051$	$\alpha = 1.5$	$\delta_k = 0.246$	$d_s = 1800$
ψ_j^g : Bomsdorf (2003)	$\delta = 0.940$		$d(w_j) = 3000 + 0.08w_j$
π_j^m, π_j^d : Stabu (2007)	$\kappa = 0.5$		$T(y)$ see text
$\pi_{ss^*}^g$: see text	$\varphi = 1.0$		APA see text

increase of married couples in the early years of life until age 35 due to high marital risk. Passing age 35, the number of married couples stays roughly constant. Finally, with survival probabilities being lower than one at retirement, the number again declines as the number of widows/widowers increases. Figure 1 also shows the fraction of married couples we obtain when applying estimated probabilities for the 1970s, i.e. from a time with much more marriages and less divorces. The solid line represents the actual data on married couples in Germany we also computed from Federal Statistical Office Germany (2007) data. Of course, this line lies somewhat in between the ones for 1970 and 2005, as we assumed steady state behavior for both the 2005 and 1970 probabilities. However, real demographics is always in transition, i.e. marital risk changes over time. We distinguish $S = 3$ educational classes

Figure 1: Fraction of married couples in every cohort



and assume that the initial distribution of men and women over the groups follows the one reported in the appendix. The respective mating probabilities $\pi^{g}_{ss^*}$ were estimated from German Socio-Economic Panel (SOEP) data of the years 1995-2007 and are reported in the appendix as well.[4]

With respect to the preference parameters, we set the intertemporal elasticity of substitution γ to 0.6, the intratemporal elasticity of substitution ρ to 0.6 and the leisure preference parameter α to 1.5. This is within the range of commonly used values (see Auerbach and Kotlikoff, 1987, İmrohoroğlu and Kitao, 2009 p.871). In order to calibrate a realistic capital to output ratio, the discount factor is set at 0.940 which implies an annual discount rate of about 1.25

[4]The SOEP data base is descried in Wagner, Frick and Schupp (2007).

percent. Finally, input share of home production κ is set to 0.5 and the externality parameter φ is set to 1.0.

With respect to technology parameters we specify the general factor productivity $\theta = 1.52$ in order to normalize labor income and set the capital share in production ε at 0.3. The annual depreciation rate for capital is set at 4.5 percent which yields a periodic depreciation rate of $\delta_k = 0.265$. The annual APA value is chosen in order to derive a replacement rate of net income of 70 percent, which yields a realistic contribution rate for Germany. As already explained, the taxation of gross income (from labor, capital and pensions) is close to the current German income tax code and the marginal tax rate schedule $T05$ which was introduced in 2005. In addition, we consider a special allowance for labor income of $d(w_j)$ which combines a fixed amount of 3000 € and an additional deduction of 0.08 percent of labor income. Given taxable income y_j, the marginal tax rate rises linearly after the basic allowance of 7800 € from 15 percent to a maximum of 42 percent when y_j passes 52.000 €. In the initial long-run equilibrium, we assume a debt-to-output ratio of 60 percent, fix the consumption tax rate at 17 percent and compute G endogenously to balance the budget.

3.2 Estimation of productivity profiles and income uncertainty

In order to estimate productivity profiles, we use inflated income data y_{it} of primary household earners from the German SOEP. Our unbalanced panel data covers full-time workers between ages 20 and 60 of the years 1984 to 2006 and was divided into different educational groups according to the International Standard Classification of Education (ISCED) of the UNESCO of 1997. In order to receive three groups, we merge levels 0 to 2 (primary and lower secondary education), levels 3 and 4 (higher secondary and post-secondary education) as well as levels 5 and 6 (tertiary education) to one group each. This approach leads us to a total of 83893 observations, where we have 11789, 55015 and 17089 observations in groups one to three, respectively.

Following Love (2007), we assume household's log-productivity to follow a deterministic trend $g_j(s)$ that only depends on agent's age and income class s plus some shock ζ that is described by an AR(1)-process, i.e. for a class s household, we have

$$\log(e_j) = g_j(s) + \zeta_j \tag{12}$$

with

$$\zeta_j = \varrho\zeta_{j-1} + \epsilon_j \quad , \quad \epsilon_j \sim N(0, \sigma_\epsilon^2) \quad \text{and} \quad \zeta_0 = 0. \tag{13}$$

Concerning our data, we therefore estimate the equation

$$\log(y_{it}) = \beta_0 + \beta_1 \text{age}_{it} + \beta_2 \text{age}_{it}^2/100 + \beta_3 \text{type}_{it} + \nu_i + \zeta_{it} \tag{14}$$

with an individual effect $\nu_i \sim N(0, \sigma_\nu^2)$ separately for any of the three educational groups s by means of GLS, assuming ζ to follow an AR(1) process as in (13). In equation (14) the regressor type_{it} is a vector of dummy coded variables for the type of job of the individual, i.e. blue collar, white collar, etc. This approach leads us to the parameter estimates shown in Table 2 (standard errors are reported in parenthesis).

Table 2: Parameter estimates for individual productivity

	Group 1	Group 2	Group 3
Intercept and type	9.6207	9.4190	8.6649
	(0.2662)	(0.1494)	(0.3116)
age term β_1	0.0437	0.0579	0.1025
	(0.0041)	(0.0025)	(0.0064)
age^2 term β_2	-0.0500	-0.0649	-0.1090
	(0.0052)	(0.0031)	(0.0074)
AR(1) correlation ϱ	0.7244	0.7826	0.7770
	(0.0119)	(0.0046)	(0.0088)
persistent variance σ_ν^2	0.0196	0.0320	0.0914
	(0.0053)	(0.0036)	(0.0083)
transitory variance σ_ϵ^2	0.0646	0.0737	0.0790
	(0.0056)	(0.0039)	(0.0076)

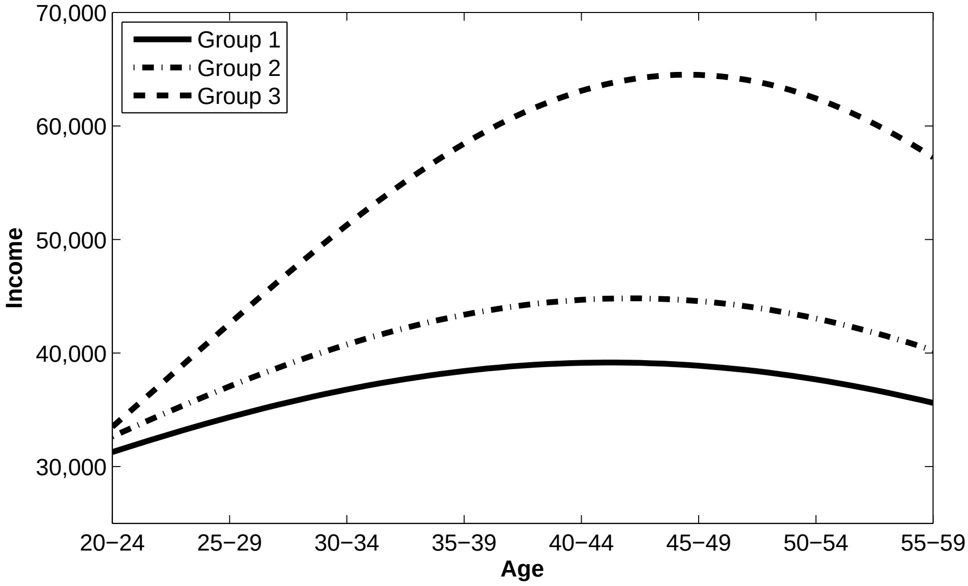
There are two things to notice. First, we find a strong AR(1) correlation of around 0.8 for the error term, which lies in the range of typical values for these types of models, see e.g. Love (2007) or İmrohoroğlu and Kitao (2009). Second, except for group 3, we see a small persistent variance, which means that our groups are strongly homogeneous. In the highest educational group, however, there is a certain chance of climbing up into the area of extraordinary high salaries. This makes the group somewhat more heterogeneous and explains a higher variance of the individual effect. The estimated income profiles can be seen in Figure 2.

For computational reasons, we finally approximate the shock ζ by a first order discrete Markov process with two nodes using a discretization algorithm as described in Tauchen (1986).

3.3 The initial equilibrium

Table 3 reports the calibrated benchmark equilibrium and the respective figures for Germany in 2007. Since men have lower survival probabilities than women after retirement, their life

Figure 2: Estimated income profiles



expectancy (at age 20) is 76.8 years while women on average become 4.3 years older. As one can see, the initial equilibrium reflects quite realistically the current macroeconomic situation in Germany.

Table 3: The initial equilibrium

	Model solution	Germany 2007
Calibration targets		
Total first marriage rate	0.587	0.550[a]
Mean age at first marriage (in years)	31.1	29.6/32.6[b]
Total divorce rate	0.391	0.410[a]
Life expectancy (women) (in years)	81.1	81.3[a]
Life expectancy (men) (in years)	76.8	76.5[a]
Pension benefits (% of GDP)	13.5	12.3[c]
Pension contribution rate (in %)	19.5	19.5[c]
Tax revenues (in % of GDP)	23.5	20.2[c]
Capital-output ratio	2.9	2.9[c]
Other benchmark coefficients		
Interest rate p.a. (in %)	4.6	–
Bequest (in % of GDP)	5.1	4.7-7.1[d]

Source: [a]CEP (2006), [b]Gude (2008), [c]IdW (2008), [d]DIA (2002, p. 19), [e]DIW (2005).

4 Simulation results

This section presents our simulation results. In order to quantify the impact of a changing family structure on macroeconomic variables and long-run welfare, we compute a new long-run equilibrium that results from the introduction of marriage and divorce probabilities of the 1970s and compare it to the one with the 2005 marital structure. This implies keeping government expenditure and public debt constant per capita and letting the consumption tax rate balance the budget. To strengthen the importance of labor income uncertainty, we always compare a situation with productivity shocks, as estimated in the previous section, with a case where productivity is deterministic over the life cycle.

In order to separate the different effects resulting from a changing family structure, we do not immediately start with the initial equilibrium as described in section 3. We rather begin with a scenario where lifespan is certain, individuals are distributed equally among educational groups and do only marry partners of the same skill group. In addition, we make the income tax system linear. For keeping the capital-output ratio constant in all initial equilibria, we furthermore assume a small open economy, i.e. factor prices do not change and the economy builds up foreign assets or debt.

We then proceed as follows: In subsection 1, we introduce lifespan uncertainty to isolate the insurance effects of the family against income and longevity risk. In the next subsection, we assume a more realistic marriage pattern and the German progressive income tax schedule. Finally, we present results from a sensitivity analysis for behavioral assumptions and the most important parameters of the model.

4.1 Gender-specific mortality and family insurance

In all our simulations we simultaneously increase marriage probabilities and reduce divorce probabilities in order to achieve a total first marriage rate of 99.2 and a total divorce rate of 15.7 which are both close to the figures during the 1970s in Germany, see CEP (2006). The mean age at first marriage (MAFM) consequently decreases from 31.1 to 29.1 years. The left part of Table 4 reports the situation when males and females have an identical and certain lifespan of 80 years (i.e. $\psi^g = 1.0$ and $J = 12$). As in this case there is no difference between males and females, both genders react absolutely in the same way.[5] We find that higher marriage probabilities and lower divorce risk increase labor supply and reduce savings. Assets are pooled when agents get married and singles take the savings of possible spouses as given. This works like a prisoner's dilemma and leads to a reduction in the purchase

[5]The case with certain income is similar to the situation analyzed in Cubeddu and Rios-Rull (2003).

Table 4: Macro and welfare effects of family formation: Lifespan uncertainty[a]

	Certain lifespan		Unisex mortality		gender-related mortality	
	Certain labor income	Uncertain labor income	Certain labor income	Uncertain labor income	Certain labor income	Uncertain labor income
A^m	-7.5	-12.4	-0.3	-8.0	1.0	-7.8
A^f	-7.5	-12.4	-0.3	-8.0	-2.9	-9.8
L^m	0.7	1.6	0.6	1.5	1.0	2.1
L^f	0.7	1.6	0.6	1.5	0.2	1.2
Y	0.7	1.6	0.6	1.5	0.6	1.7
τ_c^*	0.5	0.9	0.2	0.1	-0.2	0.2
W^m	-0.83	-0.39	-0.49	-0.46	-0.80	-0.81
W^f	-0.83	-0.39	-0.49	-0.46	-0.32	-0.38

[a] In percent of initial equilibrium, * in percentage points.

of assets. Consequently, households have to increase labor supply at older ages in order to compensate for this dilemma. In the case of uncertain income, the pooling of productivity risk in a family provides insurance against income uncertainty which leads to an additional reduction of assets of 4.9%, compared to the case with certain income, due to the reduction of precautionary savings. Assuming a small open economy, GDP obviously has to move in the same manner as labor supply. As the increase in labor supply cannot offset the fall in interest income, income tax revenues decline and the consumption tax rate has to increase in both cases. Finally, the prisoner's dilemma of marriages that leads to under-saving in the early years of life reduces welfare of both partners. Due to stronger binding liquidity constraints, high educated individuals lose less than low educated individuals. Note however, that with marriages providing insurance against income uncertainty, the reduction in welfare is much smaller in the case of uncertain income.

For quantifying the longevity insurance effect, we now introduce lifespan uncertainty into our model. In the middle columns of Table 4, we assumed unisex, averaged survival probabilities which lead to a life expectancy of 79 years for both genders. Since lifespan now is uncertain and annuity markets are absent, assets of singles and partners that both die in the same period are given as accidental bequests to working generations, whereas surviving spouses receive the whole estate if only one partner dies. Consequently, building up assets in a marriage now provides longevity insurance (Kotlikoff and Spivak, 1981), so that assets are reduced much less compared to the respective previous simulations. Labor supply is hardly effected, as the prisoner's dilemma and, consequently, under-saving in the early periods of life is still present. Due to better longevity insurance, the reduction in welfare is much smaller than in the previous simulation in the certain income case. However, with uncertain income, the reduction of precautionary savings dominates the longevity insurance effect. Hence, assets still decrease by 8% which leads to a reduction of unintended bequests and hurts future generations.

Finally, in the right part of Table 4, we let survival probabilities differ between genders, i.e. we obtain life expectancies as reported in Table 3. While the impact on GDP, tax rates and aggregate assets is only modest, we can see a clear difference between the decisions of both genders now. The increase in assets and labor supply of males and the decrease in those of females can be explained as follows: single women save and work much more compared to single men, as their expected life span is about 5 years longer. However, once married, partners make a joint savings decision for the whole family. This leads to some sort of compromise, i.e. females reduce their assets, while males increase them. Of course, due to their higher life expectancy, women now benefit much stronger from the longevity insurance effect. Consequently, now the welfare losses are higher for men and smaller for woman compared to the respective unisex mortality cases.

4.2 Educational background, mating and income taxation

So far, the two genders only differed in mortality rates. However, in reality, there is also some difference in educational backgrounds and mating behavior. We therefore now relax the assumption of equal distribution among skill groups and marriages only within the same educational levels, and use the distribution and mating matrices we estimated from SOEP data for the years 1995-2007 which are reported in the appendix. Taking a look at those, we notice that men are slightly more skilled than women and, consequently, women tend to marry singles from higher educational classes. The left part of Table 5 shows that gender-specific behavior and gains from marriage now significantly differ compared to the previous setting. Men reduce their savings even more and increase their labor supply instead, while woman further reduce their labor supply. The savings reaction of men reflects the fact that marriage now redistributes much stronger towards the female partner. The labor supply reaction is due to the fact that specialization within the marriage offers higher returns. Again at the aggregate level, one can hardly observe an impact on GDP or tax rates. Of course, with there being more redistribution towards female partners, the welfare differential between men and woman increases. Now, high educated men lose the most while low educated women benefit the most from increased marriage probabilities.

Finally, we arrive at the benchmark calibration reported in section 3 by introducing progressive income taxes and income splitting within a marriage. Higher marriage probabilities now further dampen female labor supply. However, both partners of the marriage benefit

Table 5: Macro and welfare effects of family formation: Mating and income taxation[a]

	Gender-specific education and mating		Progressive income taxation and splitting Smopec		Progressive income taxation and splitting Closed economy	
	Certain	Uncertain	Certain	Uncertain	Certain	Uncertain
	labor income		labor income		labor income	
A^m	0.0	-9.6	0.2	-5.8	0.0	-1.8
A^f	-2.8	-10.2	-2.9	-7.2	-2.6	-3.1
L^m	2.2	3.4	2.1	2.9	2.2	2.4
L^f	-0.8	0.2	-1.1	-0.3	-1.0	-0.7
Y	0.7	1.8	0.5	1.3	-0.1	-0.3
τ_c^*	-0.2	0.2	-0.3	0.0	-0.3	0.0
W^m	-1.00	-1.11	-0.74	-0.46	-0.93	-0.36
W^f	-0.15	-0.03	0.29	0.53	0.12	0.67

[a] In percent of initial equilibrium, * in percentage points.

compared to the respective previous simulations, since marriage reduces tax burdens due to income splitting. Note that the positive welfare effect is much stronger in the case of uncertain income, as the latter is more dispersed. Consequently, progressive income taxation has a stronger (positive) effect on asset accumulation and a stronger (negative) effect on labor supply in the case with uncertain income than with certain income.

If we additionally relax the assumption of a small open economy in the right part of Table 5, lower aggregate savings decrease the capital stock so that wages decrease by 0.7 and 1.2 percent in the certain and uncertain income cases, respectively. At the same time, higher interest rates dampen the reduction in savings, which results in a higher level of unintended bequests than in the small open economy case. With certain income the negative wage effect dominates, so that welfare decreases further. With uncertain income the opposite holds.

4.3 Sensitivity analysis

In this subsection, we report the sensitivity of our benchmark results with respect to some central behavioral assumptions and preference parameters.

Non-cooperative bargaining vs. family altruism

In this subsection we analyze two different ways of modeling intra-family decision making. Following Konrad and Lommerud (1995), we assume that spouses decide in a fully non-cooperative way.[6] Hence, a married person chooses consumption, leisure and savings that maximize her own utility, given the reaction function of the spouse and the fact that labor income and assets are pooled completely. The result of this decision process consequently is a non-cooperative Nash equilibrium. For better comparison, the first column of Table 7 reports once again the respective figures from the collective decision making of the benchmark simulation from Table 5. The second column displays the results from the non-cooperative bargaining model. Obviously, we now find also underprovision of assets in a marriage due to the prisoners' dilemma. An increase in marriage and a decrease in divorce rates therefore comes with an enormous decline in assets both for men and women. With respect to labor supply, we see no gender specialization anymore. In addition, non-cooperative decision making also comes with underprovision of the family public good and therefore overall labor supply increases compared to the efficient benchmark case. Due to the tremendous decline in assets the tax base of income taxation is narrowed, so that the consumption tax rate has to increase by 4.1%. Welfare of both men and women decreases due to the strengthening of the prisoners' dilemma. However, women are hurt more compared to the benchmark case as the loss of intra-family old-age insurance is especially harmful for them.

Table 6: Alternative intra-family decision making assumptions[a]

	Collective family model (benchmark)	Non-cooperative bargaining model	Altruism model
A^m	-5.8	-90.2	8.8
A^f	-7.2	-89.7	9.1
L^m	2.9	2.7	2.6
L^f	-0.3	3.4	-0.7
Y	1.3	3.1	1.0
τ_c^*	0.0	4.1	-1.7
W^m	-0.46	-1.52	25.55
W^f	0.53	-2.47	30.62

[a] In percent of initial equilibrium, * in percentage points.

As a second modeling alternative, we assume individuals to still maximize their own utility but to be completely altruistic towards their spouses. Hence, the decision problem (5) of a

[6]For a discussion of this approach see Lundberg and Pollak (1994) and Apps and Rees (2009). Non-cooperative behavior within a marriage is particularly implausible if the resulting equilibrium is inefficient. However, our results can be interpreted as a threat point for Nash bargaining after the wedding day, see Wrede (2003, p. 207).

married person of gender g changes to

$$V(z_j) = \max_{c_j, l_j} \left\{ u(c_j, h_j) + u(c_j^*, h_j) + \delta \left[\psi_{j+1}^g EV(z_{j+1}|z_j) + (1 - \psi_{j+1}^g) EV(z_{j+1}^{*,w}|z_j^*) \right] \right\}^{\frac{1}{1-\frac{1}{\gamma}}},$$

where $u(c_j, h_j)$ and $u(c_j^*, h_j)$ reflect the utilities from both partners and $(1 - \psi_{j+1}^g) EV(z_{j+1}^{*,w}|z_j^*)$ is the future utility of the widowed spouse, if the person dies.[7] Consequently, married couples now have a bequest motive which results in an increase in assets for both males and females when we raise marriage and lower divorce rates. Labor supply reacts in a similar manner as in our benchmark case, since individuals take into account their partner's utility and therefore household decision making is efficient. With the increase in assets, the income tax base is augmented and the consumption tax rate falls. As individuals now directly benefit from having a spouse through the altruistic motive, it is not surprising that increasing marriage and decreasing divorce rates come with a huge increase in welfare for both genders.

As it seems, modeling non-cooperative bargaining within the family produces unrealistic results especially in terms of asset allocation. As an alternative, the altruism model generates reasonable macroeconomic results but the welfare consequences are extremely biased.

Alternative preference parameters

In this subsection we check the sensitivity of our results with respect to some central parameters. In order to isolate risk aversion from intertemporal substitution, we follow the approach of Epstein and Zin (1991) and rewrite the preference structure of the representative consumer as

$$V(z_j) = \max_{c_j, \ell_j} \quad \left\{ u(c_j, \ell_j) + \delta \psi_{j+1}^g E \left[V(z_{j+1}|z_j)^{1-\eta} \right]^{\frac{1-1/\gamma}{1-\eta}} \right\}^{\frac{1}{1-\frac{1}{\gamma}}}.$$

The parameter η defines the degree of (relative) risk aversion. When we apply the special case $\eta = \frac{1}{\gamma}$, we are back at the traditional expected utility specification discussed above, see Epstein and Zin (1991, p. 266). Consequently, setting relative risk aversion $\eta = 1.67$ yields the benchmark equilibrium reported in Table 3. Typically, values between 1 and 5 for η are perceived as reasonable in the literature, see Meyer and Meyer (2005).

In the first line of Table 7 we replicate the respective macro and welfare effects from the middle columns of Table 5. Next, we simulate an economy with risk neutral individuals (i.e. $\eta = 0$) in order to eliminate precautionary savings. Consequently, one of the negative

[7] Note that family members in this case do not necessarily have to choose the same consumption level.

Table 7: Sensitivity analysis of reduced marital risk

η	γ	ρ	κ	φ	A^m	A^f	L^m	L^f	Y	τ_c	welfare men	welfare women
1.67	0.6	0.6	0.5	1.0	**-5.8**	**-7.2**	**2.9**	**-0.3**	**1.3**	**0.0**	**-0.46**	**0.53**
0.0					-3.9	-5.3	2.7	-0.4	1.2	-0.1	-0.43	0.57
	0.33				-6.4	-6.6	2.3	-0.6	0.9	0.1	0.02	0.79
		1.9			0.5	-2.7	0.9	-2.4	-0.7	0.8	-0.33	0.39
			0.3		-5.5	-6.8	18.8	-19.7	1.4	-0.7	1.24	2.19
				1.05	-5.6	-7.0	3.3	0.1	1.7	-0.2	0.66	1.61

[a] in percentage points.

savings effects due to higher marriage rates – namely insurance against income uncertainty – disappears which results in higher savings for both genders compared to the benchmark case. However, labor supply and welfare are hardly affected. Setting η back at 1.67 and reducing the intertemporal elasticity of substitution from 0.6 to 0.33 flattens the consumption profile and strengthens liquidity constraints at the beginning of the life cycle. As now there are nearly no savings before singles marry, the prisoner's dilemma caused by asset pooling in marriages is reduced and therefore welfare rises. In addition, as consumption is shifted towards earlier periods in life, assets do not differ that much between singles of both genders due to different life expectancies. Hence, the disparity in asset reduction between males and females nearly vanishes. In the case of an increased intratemporal elasticity of substitution, falling income tax revenues due to more marriages lead to an increase in the consumption tax rate. This forces people to substitute leisure for consumption which strongly decreases aggregate labor supply and therefore GDP. If the leisure share of men κ is reduced in the home production technology, there is much more substitution of labor towards males after marriage than in the benchmark. As men on average have a higher productivity than women, there is a positive income effect that increases welfare. Not surprisingly, the macroeconomic consequences of an increased productivity parameter of the home production function φ are very modest, but the welfare gains increase quite significantly compared to the benchmark case.

5 Conclusion

Summing up the results from the previous section, we have shown that changes in marital risk during the last decades had a profound effect on long-run macroeconomic variables and welfare. Our quantitative results indicate a significant increase in aggregate capital accumulation due to lower marriage and higher divorce probabilities. In addition, our model also accounts for the rising labor market participation of woman during the last decades. Surprisingly, the taxation of couples has a rather modest effect on the labor market behavior of women. Finally, our simulations indicate that the change in the marital structure had a significant negative welfare impact on women who lost between 0.4 and 2.2 percent of aggregate resources. The impact on men's welfare, however, could be positive or negative depending on the specific calibration.

In our sensitivity analysis we show that modeling intra-household decision making as a non-cooperative game does not seem very reasonable since it produces unrealistic results especially in terms of asset allocation. The altruism model yields a realistic macroeconomic behavior but could not be applied for a sound welfare analysis.

Of course, our model can be extended in various directions. In future work we plan to improve the modeling of women's labor supply and family consumption decision by introducing both child care periods and some explicit home production technology as in Hong (2006) or Chang and Kim (2006). This will allow us to calibrate the observed intertemporal labor supply of married and single women and distinguish between consumption of market goods, home goods and leisure. Before simulating governmental policy reforms, a natural extension would be the introduction of a transition path together with a Lump-Sum Redistribution Authority in the spirit of Auerbach and Kotlikoff (1987). With this, we will not only be able to clearer answer questions about intra- and intertemporal redistribution, but we can also measure efficiency effects of such reforms. In terms of the analysis of governmental policy, there are at least two ways to go. On the one hand, we plan to analyze the macroeconomic, efficiency and welfare effects of different family and child care policies. On the other hand, we plan to extend Hong and Rios-Rull (2007) and simulate the intergenerational welfare and efficiency consequences of social security privatization. As marriages, as well as the pension system, provide longevity insurance, it is not clear to which extend those two insurance systems are redundant. Fehr, Habermann and Kindermann (2008) find a positive role for social security due to longevity insurance, however, we can't say whether this result holds in an economy where people can get married.

Appendix: Probabilities

Table 8: Age-specific marriage and divorce rates

	2007		1970	
Age	π_j^m	π_j^d	π_j^m	π_j^d
(15-19	0.038	–	0.078	–)
20-24	0.143	0.491	0.307	0.147
25-29	0.249	0.291	0.641	0.087
30-34	0.194	0.187	0.807	0.056
35-39	0.098	0.131	0.649	0.039
40-44	0.049	0.091	0.352	0.027
45-49	0.035	0.053	0.236	0.016
50-54	0.031	0.027	0.212	0.008

Table 9: Initial distribution over educational backgrounds

Group	1	2	3
men	0.21	0.56	0.23
women	0.32	0.53	0.15

Table 10: Mating probabilities $\pi^g_{ss^*}$

males

		s^*		
		1	2	3
	1	0.56	0.40	0.03
s	2	0.31	0.61	0.08
	3	0.10	0.46	0.43

females

		s^*		
		1	2	3
	1	0.37	0.55	0.08
s	2	0.16	0.64	0.20
	3	0.05	0.29	0.67

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